

HYPERNUMBERS AND OTHER EXOTIC STUFF



Photo by Mateusz Dach

(1) MORE ON THE "ARITHMETICAL" SIDE

Tropical Arithmetics

Introduction to Tropical Geometry - Diane Maclagan and Bernd Sturmfels

<http://www.cs.technion.ac.il/~janos/COURSES/238900-13/Tropical/MaclaganSturmfels.pdf>

https://en.wikipedia.org/wiki/Min-plus_matrix_multiplication

https://en.m.wikipedia.org/wiki/Tropical_geometry#Algebra_background

https://en.wikipedia.org/wiki/Amoeba_%28mathematics%29

https://www.youtube.com/watch?v=1_ZfvQ3o1Ac (friendly introduction)

https://en.wikipedia.org/wiki/Log_semiring

<https://en.wikipedia.org/wiki/LogSumExp>

Tight spans, Isbell completions and semi-tropical modules - Simon Willerton

<https://arxiv.org/pdf/1302.4370.pdf> (one half of the tropical semiring)

Hyperfields for Tropical Geometry I. Hyperfields and dequantization - Oleg Viro

<https://arxiv.org/pdf/1006.3034.pdf> (see section "6. Tropical addition of complex numbers")

Supertropical quadratic forms II: Tropical trigonometry and applications -

Zur Izhakian, Manfred Knebusch and Louis Rowen -

https://www.researchgate.net/publication/326630264_Supertropical_Quadratic_forms_II_Tropical_Trigonometry_and_Applications
Tropical geometry to analyse demand - Elizabeth Baldwin and Paul Klemperer
http://elizabeth-baldwin.me.uk/papers/baldwin_klemperer_2014_tropical.pdf
International Trade Theory and Exotic Algebras - Yoshinori Shiozawa
<https://link.springer.com/article/10.1007/s40844-015-0012-3>

Arborescent numbers: higher arithmetic operations and division trees - Henryk Trappmann
http://eretrandre.org/rb/files/Trappmann2007_81.pdf
Tetration Reference - Henryk Trappman and Andrew Robbins
<https://math.eretrandre.org/tetrationforum/attachment.php?aid=387>
Open problems in tetration
<https://math.eretrandre.org/tetrationforum/showthread.php?tid=162>
Applications of tetration
<https://math.stackexchange.com/questions/199862/what-is-the-geometric-physical-or-other-meaning-of-the-tetration>

The family of arithmetics of Ruggero Maria Santilli
<http://www.santilli-foundation.org/docs/10.11648.j.ajmp.s.2015040501.14.pdf>
Isodual Theory of Antimatter with applications to Antigravity, Grand Unification and Cosmology
<https://www.amazon.com/Isodual-Theory-Antimatter-applications-Antigravity/dp/1402045174> (book)
Studies on Santilli's Isonumber Theory - Arun S. Muktibodh
<http://www.santilli-foundation.org/docs/pdf2.pdf>
Elements of Hadronic Mechanics III Experimental verifications - R.M.Santilli
<http://www.santilli-foundation.org/docs/elements-hadronic-mechanics-iii.compressed.pdf>
Initiating Santilli's Iso-Mathematics to Triplex Number... - Nathan O. Schmidt and Reza Katebi
<http://vixra.org/pdf/1308.0051v2.pdf>
<http://thunder-energies.com/> && <http://www.santilli-foundation.org>

The Development of Hyper-Dual Numbers for Exact Second-Derivative Calculations
Jeffrey A. Fike and Juan J. Alonso
http://adl.stanford.edu/hyperdual/Fike_AIAA-2011-886_slides.pdf

Saturation Arithmetics
https://en.wikipedia.org/wiki/Saturation_arithmetic

Symmetric level index - https://en.wikipedia.org/wiki/Symmetric_level-index_arithmetic
A Hybrid Number Representation Scheme Based on Symmetric Level-Index Arithmetic
Xunyang Shen and Peter R. Turner -
https://www.researchgate.net/publication/221142816_A_Hybrid_Number_Representation_Scheme_Based_on_Symmetric_Level-Index_Arithmetic

ZEA A zero-free exact arithmetic - Dominique Michelucci and Jean-Michel Moreau
https://www.researchgate.net/publication/220991026_ZEA_-_A_zero-free_exact_arithmetic

Algebra of screws https://en.wikipedia.org/wiki/Screw_theory#Algebra_of_screws

On quantum state of numbers - Bernard Le Stum & Adolfo Quirós

<https://arxiv.org/pdf/1310.8143.pdf>

Half-exponential function - https://en.wikipedia.org/wiki/Half-exponential_function

Matrix exponential - https://en.wikipedia.org/wiki/Matrix_exponential

Baker–Campbell–Hausdorff formula

https://en.wikipedia.org/wiki/Baker%E2%80%93Campbell%E2%80%93Hausdorff_formula

N-ary group https://en.wikipedia.org/wiki/N-ary_group

Circuits over sets of natural numbers

https://en.wikipedia.org/wiki/Circuits_over_sets_of_natural_numbers

The complexity of circuit evaluation over the natural numbers - Pierre McKenzie and Klaus Wagner

<http://www.iro.umontreal.ca/~mckenzie/Dagstuhl02.pdf>

The Unwinding Number - Robert M. Corless and David J. Jeffrey

<https://faculty.e-ce.uth.gr/akritas/CE102/p28-corless.pdf>

Generalized distributive law

https://en.wikipedia.org/wiki/Generalized_distributive_law

A Noncommutative Version of the Natural Numbers - Tyler Foster

<https://arxiv.org/pdf/1003.2081.pdf>

A new number system: Remainder numbers

<https://math.stackexchange.com/questions/2415896/a-new-number-system-remainder-numbers>

Generalization of the unit interval - William M. Cornette

https://projecteuclid.org/download/pdf_1/euclid.pjm/1102818012

Numeristics - Kevin Carmody - <https://kevincarmody.com/math/numeristics.pdf>

Construction, properties and applications of finite neofield - Anthony Donald Keedwell

https://dml.cz/bitstream/handle/10338.dmlcz/119164/CommentatMathUnivCarolRetro_41-2000-2_8.pdf

Quantity Calculus - https://en.wikipedia.org/wiki/Quantity_calculus

<http://ingvar.web03.cefit.se/wp-content/uploads/2016/02/physics6.pdf>

Metrological Thinking Needs the Notions of Parametric Quantities, Units, and Dimensions

Ingvar Johansson

Solving Cubic Equations with Curly Roots - Dan Kalman and Maurice Burke

<https://www.jstor.org/stable/10.5951/mathteacher.108.5.0392?seq=1>

The eightfold path to nonstandard analysis - Vieri Benci, Mauro Di Nasso and Marco Forti

https://www.researchgate.net/profile/Vieri_Benci/publication/228753190_The_eightfold_path_to_nonstandard_analysis/links/0deec52e248b66edc1000000/The-eightfold-path-to-nonstandard-analysis.pdf

Radical of an integer - https://en.wikipedia.org/wiki/Radical_of_an_integer

Integer square root - https://en.wikipedia.org/wiki/Integer_square_root

Quadratic residue - https://en.wikipedia.org/wiki/Quadratic_residue

Hypernumbers and Extrafunctions: Extending the Classical Calculus - Mark Burgin

<https://www.amazon.com/Hypernumbers-Extrafunctions-Extending-SpringerBriefs-Mathematics/dp/1441998748>

Ordinal number - https://en.wikipedia.org/wiki/Ordinal_number

Mex - [https://en.wikipedia.org/wiki/Mex_\(mathematics\)](https://en.wikipedia.org/wiki/Mex_(mathematics))

Parallel - [https://en.wikipedia.org/wiki/Parallel_\(operator\)](https://en.wikipedia.org/wiki/Parallel_(operator))

Alternative models of the real number line in physics - D. K. Ross

<https://link.springer.com/article/10.1007/BF02213428>

Can There Be an Alternative Mathematics, Really? - Jean Paul Van Bendegen

https://link.springer.com/chapter/10.1007%2F0-387-24270-8_30

How Much Mathematics Is “Hardwired” If Any at All - Rafael Núñez

https://cogsci.ucsd.edu/~nunez/COGS152_Readings/Nunez_ch3_MN.pdf

Fractions in transrational arithmetic - Jan A. Bregstra

<https://transmathematica.org/index.php/journal/article/view/19/23>

Continuum between addition, multiplication and exponentiation

<https://math.stackexchange.com/questions/1269643/continuum-between-addition-multiplication-and-exponentiation>

La quinta operación aritmética (The fifth arithmetical operation)

New Numerical Methods: The Rational Mean (book) - Domingo Gomez Morin

https://www.amazon.com/gp/product/1520717245/ref=dbs_a_def_rwt_hsch_vapi_tpbk_p1_i1

<https://www.youtube.com/watch?v=6IORU03yuvY>

AULOS. LA OTRA LUZ. Music and Consonance. New musical scale not based on the Octave.

https://www.youtube.com/watch?v=gbK_V_7ivDA

<https://domingogomezmorin.wordpress.com/>

Setoid - <https://en.wikipedia.org/wiki/Setoid>

Some ternary quasigroups over small sets

http://tamivox.org/dave/math/tern_quasi/index.html

The five fundamental operations of mathematics: addition, subtraction, multiplication, division, and

modular forms - Kenneth A. Ribet – <https://math.berkeley.edu/~ribet/trinity.pdf>

Engel expansion - https://en.wikipedia.org/wiki/Engel_expansion

Arithmetic Geometric Mean – https://en.wikipedia.org/wiki/Arithmetic%E2%80%93geometric_mean

Gauss, Landen, Ramanujan, the Arithmetic-Geometric Mean, Ellipses, π , and the Ladies Diary

Gert Almkvist and Bruce Berndt - https://link.springer.com/chapter/10.1007%2F978-3-319-32377-0_8

The total differential, the Cauchy-Riemann equations and the Elysian infinitesimals - Kerry Bemis

Heinz mean - https://en.wikipedia.org/wiki/Heinz_mean
Identric mean - https://en.wikipedia.org/wiki/Identric_mean
Logarithmic mean - https://en.wikipedia.org/wiki/Logarithmic_mean

Knot sum - <https://mathworld.wolfram.com/KnotSum.html>

Hypertranscendental number - https://en.wikipedia.org/wiki/Hypertranscendental_number
Infinite compositions of analytic functions
https://en.wikipedia.org/wiki/Infinite_compositions_of_analytic_functions

Monus - <https://en.wikipedia.org/wiki/Monus>
Racks and quandles - https://en.wikipedia.org/wiki/Racks_and_quandles
Absorption law - https://en.wikipedia.org/wiki/Absorption_law

A quest for Exactness : machines, algebra and geometry for tractional constructions of differential equations -Pietro Milici – <https://tel.archives-ouvertes.fr/tel-01889365/document>
(See section "7.3 Open problems and perspectives")

Multiplicative calculus - https://en.wikipedia.org/wiki/Multiplicative_calculus
Subderivative <https://en.wikipedia.org/wiki/Subderivative>
Fractal derivative - https://en.wikipedia.org/wiki/Fractal_derivative

Alternative mathematical notation and its applications in calculus - Jakub Marian
https://jakubmarian.com/data/bachelor_thesis.pdf

Mathematics Without Numbers Towards a Modal-Structural Interpretation - Geoffrey Hellman
<https://www.amazon.com/Mathematics-without-Numbers-Modal-Structural-Interpretation/dp/0198240341>
Science Without Numbers A Defense of Nominalism - Hartry Field
<https://www.amazon.com/Science-without-Numbers-Hartry-Field/dp/0198777922>

Los misterios de la fracción prohibida - Claudi Alsina and Carme Burgués
The mysteries of the forbidden fraction (title translated)
<https://revistasuma.es/IMG/pdf/56/039-042.pdf>
Mediant - [https://en.wikipedia.org/wiki/Mediant_\(mathematics\)](https://en.wikipedia.org/wiki/Mediant_(mathematics))
https://en.wikipedia.org/wiki/Ford_circle
https://en.wikipedia.org/wiki/Minkowski%27s_question-mark_function

Dialogue on n colored numbers - Armahedi Mahzar
https://issuu.com/armahedimahzar/docs/dialogue_on_n-colored_nubers

https://en.wikipedia.org/wiki/Additive_number_theory
https://en.wikipedia.org/wiki/Zero-sum_problem
https://en.wikipedia.org/wiki/Subset_sum_problem
https://en.wikipedia.org/wiki/Restricted_sumset#Cauchy%E2%80%93Davenport_theorem

Some remarks on the pseudo-linear algebra - Andrea markova
<https://www.sav.sk/journals/uploads/1203130414marko.pdf>
Pseudo-arithmetical operations as a basis for the general measure and integration theory - Pietro

Benvenuti and Radko Mesiar - <https://www.sciencedirect.com/science/article/pii/S0020025503002111>

Polylogarithmic function https://en.wikipedia.org/wiki/Polylogarithmic_function

Hofstadter sequences - https://en.wikipedia.org/wiki/Hofstadter_sequence

Mallows' Sequence - <https://mathworld.wolfram.com/MallowsSequence.html>

Negative Math: How Mathematical Rules Can Be Positively Bent (book) - Alberto A. Martínez
<https://www.amazon.com/Negative-Math-Mathematical-Rules-Positively-ebook/dp/B07DMVNZVP>
(Algebra of quantities, history and variations of the algebra of signs)

Interval Arithmetic - https://en.wikipedia.org/wiki/Interval_arithmetic

Theories of Interval Arithmetic Mathematical Foundations and Applications - Hend Dawood
(book)https://www.academia.edu/1976964/Theories_of_Interval_Arithmetic_Mathematical_Foundations_and_Applications

Graphs operations - https://en.wikipedia.org/wiki/Graph_operations

T.N.P - Tnp Socratis - <https://groups.google.com/forum/#!forum/it.scienza.matematica>

Summation $1+2+3+4+\dots$

https://en.wikipedia.org/wiki/1_%2B_2_%2B_3_%2B_4_%2B_%E2%8B%AF

Umbral Calculus - https://en.wikipedia.org/wiki/Umbral_calculus

Progress Report on Hyper-operations (Zeration)

<https://math.eretrandre.org/tetrationforum/attachment.php?aid=251>

Ackermann's Function and New Arithmetical Operations (zeration)

[http://www.rotarysaluzzo.it/Z_Vecchio_Sito/filePDF/Iperoperazioni%20\(1\).pdf](http://www.rotarysaluzzo.it/Z_Vecchio_Sito/filePDF/Iperoperazioni%20(1).pdf)

Constantin A. Rubtsov and Giovanni F. Romerio

Constant problem - https://en.wikipedia.org/wiki/Constant_problem

Theory of holors (book) - Parry Moon and Domina Eberle Spencer

<https://www.amazon.com/Theory-Holors-Generalization-Moon-Spencer/dp/0521019001>

J vocabulary- <https://code.jssoftware.com/wiki/NuVoc>

Generalized inverse - https://en.wikipedia.org/wiki/Generalized_inverse

Supermatrix - <https://en.wikipedia.org/wiki/Supermatrix>

Hyperdeterminant - <https://en.wikipedia.org/wiki/Hyperdeterminant>

...some others can be found in

https://en.wikipedia.org/wiki/List_of_types_of_numbers

(2) MORE ON THE "NUMERAL" SIDE

Lunar Arithmetic or Dismal Arithmetics - David Applegate, Marc LeBrun and N. J. A. Sloane

<https://cs.uwaterloo.ca/journals/JIS/VOL14/Sloane/carry2.pdf>

<https://www.youtube.com/watch?v=cZkGeR9CWbk>

<http://www.info.deis.unical.it/~yaro/Numerals%20and%20Factorization.pdf>

Balanced Ternary - https://en.wikipedia.org/wiki/Balanced_ternary

https://pt.wikipedia.org/wiki/Tern%C3%A1rio_balanceado#/media/Ficheiro:Balanced_ternary.svg

Double-Base Number System for Multi-Scalar Multiplications

Christophe Doche, David R. Kohel and Francesco Sica

<https://www.iacr.org/archive/eurocrypt2009/54790501/54790501.pdf>

Skew binary number system - https://en.wikipedia.org/wiki/Skew_binary_number_system

Two Skew-Binary Numeral Systems and One Application - Amr Elmasry and Jyrki Katajainen

<http://cphstl.dk/Paper/TOCS-2011/journal.pdf>

Zero Displacement Ternary Number System : the most economical way of representing numbers -

Fernando Guilherme Silvano Lobo Pimentel

[https://www.researchgate.net/publication/](https://www.researchgate.net/publication/258241283_Zero_Displacement_Ternary_Number_System_the_most_economical_way_of_representing_numbers)

[258241283_Zero_Displacement_Ternary_Number_System_the_most_economical_way_of_representing_numbers](https://www.researchgate.net/publication/258241283_Zero_Displacement_Ternary_Number_System_the_most_economical_way_of_representing_numbers)

Quote Notation - Eric C. R. Hehner and R. N. S. Horspool

<http://www.cs.toronto.edu/~hehner/ratno.pdf>

https://en.wikipedia.org/wiki/Quote_notation

Beyond the Complexes: Toward a lattice based number system - J. Köpflinger, J. A. Shuster

<https://www.cs.du.edu/~petr/milehigh/2013/Koeplinger.pdf>

Linear Numeral System - Ian Mackie - <http://www.ianmackie.com/papers/linns.pdf>

New approach could sink floating point computation, John Leroy Gustafson

<https://www.nextplatform.com/2019/07/08/new-approach-could-sink-floating-point-computation/>

https://en.wikipedia.org/wiki/Double-precision_floating-point_format

The residue logarithmic number system: Theory and implementation - Mark G. Arnold

[https://www.researchgate.net/publication/](https://www.researchgate.net/publication/4156476_The_residue_logarithmic_number_system_Theory_and_implementation)

[4156476_The_residue_logarithmic_number_system_Theory_and_implementation](https://www.researchgate.net/publication/4156476_The_residue_logarithmic_number_system_Theory_and_implementation)

A Low-Power Two-Digit Multi-dimensional Logarithmic Number System Filterbank Architecture for a Digital Hearing Aid -- Roberto Muscedere, Vassil Dimitrov, Graham Jullien and William Miller

https://www.researchgate.net/publication/26532063_A_Low-Power_Two-Digit_Multi-dimensional_Logarithmic_Number_System_Filterbank_Architecture_for_a_Digital_Hearing_Aid

Methodology of numerical computations with infinities and infinitesimals - Yaroslav D. Sergeyev

[http://www.theinfinitycomputer.com/The_second_paper_to_read_\(Lagrange_Lecture\).pdf](http://www.theinfinitycomputer.com/The_second_paper_to_read_(Lagrange_Lecture).pdf)

<https://www.numericalinfinities.com/>

Hetero Base Arithmetic Operation - Raghavendra Lingayya (???)
<http://www.numbersystem.org/hetero-base-arithmetic-operations.html>

Zot-Binary: a new numbering system with an application on big-integer multiplication - Shahram Jahani and Azman Samsudin - <http://www.jatit.org/volumes/Vol48No1/5Vol48No1.pdf>

Universal Script <http://www.dscredit.org/> Matthew DeBlock
(Uscript is universal logographic language based on math and physics)

Decimal Fractions - https://en.wikipedia.org/wiki/Simon_Stevin#Decimal_fractions

A Number System with Continuous Valued Digits and Modulo Arithmetic - Aryan Saèd, Majid Ahmadi and Graham A. Jullien - <https://www.academia.edu/13000520/>

A_number_system_with_continuous_valued_digits_and_modulo_arithmetic
Hereditary Base notation -
https://en.wikipedia.org/wiki/Goodstein%27s_theorem#Hereditary_base-n_notation

New Arithmetic Algorithms for Hereditarily Binary natural numbers - Paul Tarau
<https://www.cse.unt.edu/~tarau/research/2014/HBinX.pdf>

Predicting Improper Fractional Base Integer Characteristics - Billy Dorminy
<http://educ.jmu.edu/~lucassk/Papers/DorminyFracBase.pdf>

Horus Eye Fractions - https://en.wikipedia.org/wiki/Eye_of_Horus#Mathematics
Finger Binary - https://en.wikipedia.org/wiki/Finger_binary
Nemeth braille - https://en.wikipedia.org/wiki/Nemeth_Braille
Bibi-binary -- <https://en.wikipedia.org/wiki/Bibi-binary>

Quater-imaginary base - https://en.wikipedia.org/wiki/Quater-imaginary_base

QUANTUM-LANGUAGE-PARSE-SYNTAX-GRAMMAR
https://en.wikipedia.org/wiki/David_Wynn_Miller#Miller's_description_of_his_work_and_views
<https://github.com/lismore/MathematicalInterfaceForLanguage/blob/master/README.md>
<https://dwmlc.com/>

The Denormal Logarithmic Number System - Mark G. Arnold Sylvain Collange
https://www.researchgate.net/publication/262371524_The_Denormal_Logarithmic_Number_System

The generalized golden proportions, a new theory of real numbers, and ternary mirror-symmetrical arithmetic - Alexey Stakhov - <http://fs.unm.edu/SN/TheGeneralizedGolden.pdf>

Construction of Algorithms for Parallel Addition - Jan Legersky and Milena Svobodová
https://jan.legersky.cz/talks/ConstructionParAddAlg_WorkshopOnAutomaticSequences.pdf

On-line algorithms for multiplication and division in real and complex numeration systems - Marta Brzicová, Christiane Frougny, Edita Pelantová and Milena Svobodová
<https://arxiv.org/abs/1610.08309v5>

Computing with Exact Real Numbers in a Radix-r System - Alexander Kaganovsky

https://www.researchgate.net/publication/220368828_Computing_with_Exact_Real_Numbers_in_a_Radix-r_System

A variant of Ostrowski numeration - Emmanuel Cabanillas

<https://arxiv.org/pdf/1904.01874v2.pdf>

https://oeis.org/wiki/LCM_numerical_system

https://oeis.org/wiki/Factorial_numerical_system

https://en.wikipedia.org/wiki/Factorial_number_system

https://oeis.org/wiki/Primorial_numerical_system

<http://www.thefullwiki.org/Combinadic>

Octomatics number system - <http://octomatics.org/>

Sandpiles - Luis David Garcia-Puente

<https://www.youtube.com/watch?v=1MtEUErz7Gg>

<http://people.reed.edu/~davidp/>

Super omega - https://en.wikipedia.org/wiki/Chaitin%27s_constant#Super_Omega

Esolang – https://esolangs.org/wiki/Main_Page

https://en.wikipedia.org/wiki/Approximate_number_system

https://en.wikipedia.org/wiki/Numerical_cognition

https://en.wikipedia.org/wiki/Number_sense_in_animals

Together with dyscalculia, ageometresia, dysgraphia, financial illiteracy

https://en.wikipedia.org/wiki/Innumeracy_%28book%29

<https://www.andnextcomesl.com/2019/10/hypernumeracy.html>

Location arithmetic - https://en.wikipedia.org/wiki/Location_arithmetic

Yupana - <https://en.wikipedia.org/wiki/Yupana>

...some can be found in the following wikipedia links :

https://en.wikipedia.org/wiki/List_of_numerical_systems

https://en.wikipedia.org/wiki/Category:Non-standard_positional_numerical_systems

https://en.wikipedia.org/wiki/Non-standard_positional_numerical_systems

Real Computation https://en.wikipedia.org/wiki/Real_computation

Hypercomputation <https://en.wikipedia.org/wiki/Hypercomputation>

Unconventional computing (list) https://en.wikipedia.org/wiki/Unconventional_computing

(3) MORE ON THE "GEOMETRICAL" SIDE

Cubic Pythagoras – Luis Teia (pythagoras with cubes instead of squares)

<https://wonderfulengineering.com/pythagoras-theorem-has-been-upgraded-to-3d-and-now-requires-a-120-page-proof/>
https://www.youtube.com/channel/UCcoPpQFHQsv6pDzMgVI_pRw/videos?view=0&sort=dd&shelf_id=0

A Mathematical Theory of Origami Constructions and Numbers - Roger C. Alperin

<https://arxiv.org/pdf/math/9912039v1.pdf>

Teoría de Galois tras el Origami - Alberto Garcia Diaz

<https://riull.ull.es/xmlui/bitstream/handle/915/5795/Teoria%20de%20Galois%20tras%20el%20origami.%20Por%20que%20el%20origami%20resuelve%20los%20problemas%20geometricos%20clasicos%20de%20la%20Antigua%20Grecia..pdf?sequence=1&isAllowed=y>

Origami-Constructible Numbers - James King

<https://www.cs.mcgill.ca/~jking/papers/origami.pdf>

Origami and Partial Differential Equations - Bernard Dacorogna, Paolo Marcellini and Emanuele Paolini

Theory of 3D complex space and complex number of 3D space, applications and experimental validation techniques - L.T. Abobda

https://www.researchgate.net/publication/301627462_Theory_of_3D_complex_space_and_complex_number_of_3D_space_applications_and_experimental_validation_techniques

Hoop Algebras - Roger Beresford

<https://library.wolfram.com/infocenter/MathSource/6198/>

<https://demonstrations.wolfram.com/author.html?author=Roger+Beresford>

https://library.wolfram.com/infocenter/search/?search_results=1&search_person_id=4705

<https://mathworld.wolfram.com/AlgebraicLoop.html>

https://groupprops.subwiki.org/wiki/Moufang_loop (Ruth Moufang)

Smarandache Loops - W. B. Vasantha Kandasamy

<http://fs.unm.edu/Vasantha-Book4.pdf>

Truly hypocomplex numbers : Unification of numbers and vectors - Redouane Bouhennache

<https://arxiv.org/pdf/1409.2757.pdf>

On a novel 3D hypercomplex number system - Shlomo Jacobi

<https://arxiv.org/pdf/1509.01459.pdf>

Hypercomplex number in three dimensional spaces - Abdelkarim Assoul

https://www.researchgate.net/publication/308969073_Hypercomplex_number_in_three_dimensional_spaces_hal-01686021

[308969073_Hypercomplex_number_in_three_dimensional_spaces_hal-01686021](https://www.researchgate.net/publication/308969073_Hypercomplex_number_in_three_dimensional_spaces_hal-01686021)

Introduction to the General Trigonometry in Euclidian 2D-space - Claude Ziad Bayeh

<http://www.wseas.us/e-library/transactions/mathematics/2012/53-882.pdf>

Solving Quaternion Quadratic Equations - Peter Michael Jack <https://archive.org/details/q2wp01>

A System of Three-Dimensional complex variables - E. Dale Martin

<https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19880004569.pdf>

Rational trigonometry - Norman J. Wildberger

<https://www.youtube.com/user/njwildberger>

https://en.wikipedia.org/wiki/Rational_trigonometry

Generalizaciones de los números: de la aritmética a las variedades diferenciables -

Fernando Etayo Gordejuela

[https://repositorio.unican.es/xmlui/bitstream/handle/](https://repositorio.unican.es/xmlui/bitstream/handle/10902/13817/2016GacRSocMatEspGeneralization.pdf?sequence=1&isAllowed=y)

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Sinc function - https://en.wikipedia.org/wiki/Sinc_function

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